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For the solution of mechanical problems, two methods in general present themselves; the one furnished by the variation of parameters, or constants, which complete the integral obtained by the first approximation,—the other furnished by the integration of the differential equations by means of indeterminate coefficients, or some equivalent method. Each of these methods is applicable to the theory of the perturbations of the heavenly bodies, and they lead to expressions which are of course substantially identical, but which do not appear in the same shape except after certain transformations.

The object of the author in the present paper is to effect transformations, by which their identity is established, making use of the developments given in his former papers, published in the *Philosophical Transactions*. The identity of the results obtained by either methods affords a confirmation of the exactness of those expressions.

Sir Charles Bell's paper "On the Organs of the Human Voice" was then read in continuation.

February 16, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The reading of Sir Charles Bell's paper "On the Organs of the Human Voice," was resumed and concluded.

The author complains that the actions of the organs of the voice have been negligently treated by physiologists, and that many of the offices of the structures subservient to that function have been overlooked; and expects that the study of them will lay a foundation for prosecuting the intricate anatomy of the nerves of the neck, which he proposes to himself as an ulterior object. The subjects to which he particularly directs his attention in the present paper, are the Muscularity of the Trachea, the Position of the Thyroid Gland, and the Action of the Pharynx, which he alleges to have been entirely omitted in previous systematic accounts of articulate language.

The trachea is strengthened by imperfect circles of cartilage, the ends of which are united at the back part of the tube by a transverse layer of muscular fibres,—a structure which is very distinctly seen in the horse. This transverse muscle is an antagonist to the elasticity of the cartilages, and the effect of its action during expiration is, by contracting the diameter of the tube, to favour the propulsion of the mucous secretion, which may have been accumulated in the passage, and to contribute effectually to expel it by the effort of coughing. The same action leads also to the expulsion of foreign bodies which may have accidentally got into the trachea. In birds, where the inner surface of the passage is without moisture, no such provision was required; and accordingly we find the cartilages of the trachea are complete circles, not admitting of contraction.

The author considers the thyroid gland as serving the purpose of interrupting the vibrations of the cartilages of the trachea, to which it is closely attached, especially when pressed against it by the actions of the flat muscles which extend over it. If sound were given out by the vibrations of the trachea, it would interfere with the distinctness of the voice. The thyroid gland is, therefore, placed low in the larynx, and on the upper part of the trachea, for the purpose of checking the vibrations of that tube, and suppressing the sounds that would thence be produced. In birds, where the voice originates in the inferior larynx, and is propagated along the trachea, the structure of that tube is adapted to vibration, the circles of cartilage being complete, and there is no thyroid gland.

In man, the primary source of the voice is the vibration of the chordæ vocales, or ligaments of the glottis, acted upon by the impulsion of the air passing by them. The proper degree of tension is given by these ligaments by the action of the muscles, which adjust their position with the greatest accuracy. The movements of the chest, which regulate the expulsion of the air, are at the same time adapted with great nicety to the production of the required effect. The sacculi laryngis also contribute to give greater extent and freedom to the vibrations of the glottis. It is by the concurrent action of these organs that the breath, which under ordinary circumstances of respiration is inaudible, becomes *vocalized*, or thrown into sonorous undulations.

The author then gives an anatomical description of the pharynx and mouth, which together constitute an irregular cavity, extending from the glottis to the lips and nostrils, and of which the various changes of dimension and of form effect corresponding changes in the undulations into which the air is originally thrown by the vibrations of the glottis, and produce the different modifications of the voice. The most important are those which constitute articulate sounds. The simple vocal tones, or vowels, are greatly modified by the mere elongation or shortening of this cavity. But even in the formation of these, the contraction and appulse of the pharynx acts an important part; and in the articulation of the consonants it is a principal agent; its smaller cavity being, upon a well-known hydrostatic principle, substituted with great economy of power for the more capacious cavity of the chest. In pronouncing the explosive consonants, such as B, D, and G, the velum pendulum is raised, and, acting as a valve, closes the posterior nares; and the mouth being also closed, the vocalized breath, which continues to ascend through the glottis, suffers condensation, and gives rise to the faint sound which precedes the explosion consequent upon the opening of the closed cavity. This opening takes place, either by the separation of the lips, or by the removal of the tongue from the teeth, or palate, to which it had been applied. These previous actions of the pharynx and glottis are the circumstances which distinguish the sound of these letters from their corresponding mute consonants, P, T, and K. Thus the consonants, classed according to their formation in the mouth, either by the closed lips, the meet-

ing of the lips and teeth, or the meeting of the tongue and palate, admit of varieties dependent on the actions of the pharynx and velum palati. The emphasis and accent given to particular syllables arise from two sources: namely, the variation in the action of the chest, and in the action of the pharynx.

This minute accommodation of action evinces not merely the perfection of the organ, but also its great subordination to the will; and in this respect the muscular apparatus of the throat admits of comparison with the delicate adjustments in the eye. Stammering arises, not from the defect in any single part, but from imperfect power of combining the requisite actions.

The author concludes by enumerating the variety of actions which must be combined before a word is uttered: namely, the compression of the thorax, the adjustment of the glottis, the elevation or depression of the larynx, and the contraction of the pharynx. He also adduces proofs of the correctness of the opinions advanced in this paper, drawn from the effects of accident and of disease occurring under his own observation; and from which he draws the following conclusions:—That the trachea gives out no sound of itself; that when the area of the passage is much diminished, the column of air has not sufficient force to move the chordæ vocales; that whatever interferes directly with the motion of the glottis reduces the voice to a whisper; that any permanent opening or defect of the velum, which prevents the distention of the pharynx and the closing of the posterior nares, renders articulation defective; that the obstruction or removal of the cells of the face deprives the voice of its body and clearness; and that nervous relaxation of the muscles of the throat is productive of great alteration in the voice. Hence the author infers the necessity of the numerous nerves which are distributed to these organs.

February 23, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,

President, in the Chair.

The reading of a paper, entitled, "On the Inverse Ratio which subsists between Respiration and Irritability in the Animal Kingdom; and on Hybernation," by Marshall Hall, M.D. F.R.S.E., communicated by J. G. Children, Esq. Sec. R.S. was commenced.

March 1, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,

President, in the Chair.

Dr. Hall's paper was resumed, and read in continuation.